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THE INFLUENCE OF GROWTH MEDIA, TEMPERATURES, AND LIGHT INTENSITIES ON ASPEN ROOT AND TOP GROWTH

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ABSTRACT

Root and top growth of aspen cuttings in three soils (sand, loam, and clay) were studied in a controlled environmental chamber. The cuttings were exposed to two light intensities (2,000 ft.-c. and 600 ft.-c.) for 50 days at each of three temperatures (10°, 18°, and 27° C.). Root growth in loam soil was favored when plants were grown at 18° C. but at 27° C. the top growth was erratic and root growth was small. At all temperatures and light intensities, the plants growing in sand and clay produced smaller yields of roots and less top growth than did those growing in loam. Light intensity significantly influenced root growth only in loam soil at 18° C. Top growth was not significantly influenced by light intensity at all three temperatures.

Little is known of the effect of selected environmental factors upon growth of aspen (*Populus tremuloides* Michx.) under controlled conditions. Farmer[2] found that a reduction of light intensity from 1,700 to 500 ft.-c. was accompanied by a significant reduction in height growth of aspen cuttings at 24.4° C. day--21.6° C. night. At 21.1° C. day--18.9° C. night, no significant difference in height growth attributable to light intensity was observed. Results were interpreted in terms of the relation between photosynthetic accumulation and respiratory loss of energy as affected by temperature and light.

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[2] Farmer, R. E., Jr. Effect of light intensity on growth of *Populus tremuloides* cuttings under two temperature regimes. Ecology 44: 409-411. 1963.

Stoeckeler[3] discovered the highest site index in aspen growing on soils with a silt plus clay content of approximately 50 percent while doing an extensive site evaluation of Minnesota and Wisconsin aspen stands. He attributed this to a combination of greater nutrient content in the finer textured soils and the favorable moisture conditions prevailing at this 50-percent content of fine particles.

MATERIALS AND METHODS

During late August and early September, aspen roots were dug from the upper $1\frac{1}{2}$ feet of soil under a single clone near Logan, Utah. A brief description of the site has been published.[4] All roots removed were cut into 3-inch lengths and replanted the same day. Each root cutting was allowed to develop a sprout, and the sprout a small adventitious root system. Greenhouse temperatures were maintained at approximately 19±5° C. during this period.

The sprouts then were selected at random and transplanted into the clay, sand, and loam soils (table 1 describes these soils). Each flat of soil contained one plant which was still attached to its approximately 1-inch diameter root stock. Three plants were grown under low light intensity and four plants under high light intensity in each soil for 50 days at temperatures of 10°, 18°, and 27° C. Light intensities of 2,000 ft.-c. and 600 ft.-c. were applied at each temperature. The diurnal cycle consisted of 15 hours illumination and 9 hours darkness. The controlled environmental chamber had a light source in the ceiling consisting of forty-four 8-foot-long G.E. power-groove fluorescent tubes and twenty-eight 50-watt Ken-Rad 300-volt incandescent lamps.[5] Maximum light output at 3 feet below the source was 2,000 ft.-c.

Plants were well watered, but the soil was not saturated. Soil moisture availability was always near 0.3 bar of suction at the bottom of the flat and from 0.6 bar to 5 bars of suction near the surface at the time of watering.

Table 1.--Properties of the soils used in this study

Soil class	Sand	Silt	Clay	Exch. K.	Avail. P	Total N
	Percent	Percent	Percent	Meq./100 gms.	Lbs. P_2O_5/A.	Percent
Sand	100	0	0	0.04	3	0.005
Clay	7	35	58	.50	43	.092
Loam	48	30	22	1.36	390	.363

[3] Stoeckeler, J. H. Soil factors affecting the growth of quaking aspen forests in the Lake States. Univ. Minn. Agr. Exp. Sta. Tech. Bull. 233, 48 pp., illus. 1960.

[4] Gifford, G. F. Aspen root studies on three sites in Northern Utah. Amer. Midl. Natur. 75: 132-141. 1966.

[5] Trade names as used herein are solely for identification and do not imply endorsement by the U.S. Forest Service.

RESULTS

Tests for significance were made among the various growth media and light intensities within each temperature regime. Statistical evaluation among temperature regimes was not possible.

Plants grown in loam at 18° C. under 2,000 ft.-c. produced more than three times the weight of roots as did those grown in sand and clay (table 2). Within the loam, the root yield from plants grown under 2,000 ft.-c. was significantly greater than that from plants under 600 ft.-c. illumination. There were no significant differences among growth media or light intensities at either 10° or 27° C.

Table 2.--Average root yield under selected environmental conditions [1]

(In grams)

Soil class	600 ft.-c.			2,000 ft.-c.		
	10° C.	18° C.	27° C.	10° C.	18° C.	27° C.
Sand	0.34	1.05	1.61	0.80	1.24	2.00
Clay	.36	.96	1.43	.44	1.14	1.22
Loam	.46	*1.80	1.46	1.22	**3.92	2.13

[1] Tabulated values are total root weights, which are the weights before placing plants in the growth chamber plus the growth of roots while in the chamber.

*Significantly different, at 5-percent probability level, from the growth in loam at 18° C. under 2,000 ft.-c.

**Significantly different, at 1-percent probability level, from the other values in the same column.

Plants grown in loam under 2,000 ft.-c. at both 18° and 27° C. produced significantly greater top growth than did plants grown in clay or sand at the same temperatures (table 3). Growth patterns of plants in the loam at 27° C. were erratic; new growth resulted from either or both the apical and lateral buds breaking dormancy. No significant differences in top growth occurred among growth media or light intensities at 10° C., or among light intensities at 18° or 27° C.

Table 3.--Average top growth under selected environmental conditions

(In grams)

Soil class	600 ft.-c.			2,000 ft.-c.		
	10° C.	18° C.	27° C.	10° C.	18° C.	27° C.
Sand	0.78	1.54	1.18	1.43	1.67	1.82
Clay	.44	1.45	1.22	.76	1.19	1.49
Loam	1.23	2.71	1.81	2.15	**4.16	**4.24

**Significantly different, at 1-percent probability level, from the other values in the same column.

DISCUSSION

The lack of significant top and root growth at 10° C., a marked increase in growth in loam soil at 18° C., and poor root growth combined with erratic top growth in loam soil at 27° C. provides some new insight into the physiology of aspen. Lack of growth and the insignificance of light intensity at 10° C. supports Farmer's conclusions[6] concerning a relationship, governed by temperature and light, between photosynthetic accumulation and respiratory loss of energy in aspen. According to this theory, enough photosynthesis occurred under the cool treatment (10° C.) so that growth under 600 ft.-c. was not limited by a shortage of available substrate. Instead, temperature probably was the limiting factor. In loam soil, from which adequate nutrients were available, the marked increase in growth at 18° C. and the significant difference in root growth among light intensities then reflects a condition of more favorable temperature but a greater respiration loss relative to photosynthate accumulation. Differences occurring among light intensities at this temperature reflect differing rates of photosynthesis. At 27° C., root growth was inhibited, perhaps due to destruction or alteration of certain root growth hormones or deactivation of the enzymes that utilize these hormones. At this high temperature, any photosynthate remaining after consumption by respiration was undoubtedly used in the erratic growth of tops.

Nutritional properties of the three media apparently influenced growth of aspen. A greater root growth occurred in those soils having high fertility levels of such elements as phosphorus, nitrogen, and potassium (tables 1 and 2). These results support Stoeckeler's site productivity work[7] under field conditions. It is well known that nutrient status of plants in general is extremely important to the rate of photosynthesis. The lack of nutrients probably explains the poor plant response in clay and sand to the favorable 18° C. temperature regime.

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[6] See footnote 2.

[7] See footnote 3.